CLAIMS

1. A method of in-channel estimation of the OSNR of an optical signal comprising a series of transmitted data units, each data unit having one of a discrete set of different amplitudes, the method comprising:

a) selecting a portion of the signal;

b) measuring, at least once, at least an indication of the selected portion of the signal;

c) repeating selecting a portion of the signal, and measuring; and

d) estimating the OSNR from the results of at least one of the measurements, wherein consecutive measurements begin at times which differ by more than a shortest interval from one data unit to the next data unit.

2. A method according to claim 1, and including transforming the selected portion of the signal before measuring, wherein the indication of the selected portion of the signal comprises the transformed signal.

3. A method according to claim 2, wherein selecting a portion of the signal comprises temporally gating the signal to admit a sequence of N data units, where N is an integer, and repeating selecting a portion of the signal comprises repeating the temporal gating with the same or a different integer N.

4. A method according to claim 1, wherein the data units are transmitted at substantially same time intervals.

5. A method according to claim 1, wherein estimating the OSNR comprises determining a difference between the result of the at least one measurements, and an expected noiseless result of said measurement.

6. A method according to claim 5, and including calculating the expected noiseless result for the at least one measurements.

7. A method according to claim 3, wherein repeating the temporal gating comprises using a same N for each of a plurality of the repetitions.

8. A method according to claim 7, wherein said N is greater than 7.

9. A method according to claim 7, wherein said N is 7.

10. A method according to claim 7, wherein said N is 6.

11. A method according to claim 7, wherein said N is 5.

12. A method according to claim 7, wherein said N is 4.

13. A method according to claim 7, wherein said N is 2 or 3.

14. A method according to claim 1, wherein the discrete set comprises only two different amplitudes.

15. A method according to claim 1, wherein one of the amplitudes in the discrete set is zero.

16. A method according to claim 3, wherein, for at least one repetition, gating the signal comprises blocking N/2 or fewer data units after admitting the sequence of N data units.

17. A method according to claim 3, wherein, for at least one repetition, gating the signal comprises blocking between N/2 and N data units after admitting the sequence of N data units.

18. A method according to claim 3, wherein, for at least one repetition, gating the signal comprises blocking between N and 2N data units after admitting the sequence of N data units.

19. A method according to claim 3, wherein, for at least one repetition, gating the signal comprises blocking more than 2N data units after admitting the sequence of N data units.

20. A method according to claim 3, wherein the transformation is linear.

21. A method according to claim 2, wherein the transformation is nonlinear.

22. A method according to claim 20, wherein the transformation comprises a frequency filter.

23. A method according to claim 22, wherein the frequency filter comprises a low-pass filter.

24. A method according to claim 23, wherein the filter is symmetric around the carrier frequency of the optical signal.

25. A method according to claim 24, wherein the filter has at least one local maximum located on each side of the carrier frequency.

26. A method according to claim 23, wherein the filter comprises a Kaiser window.

27. A method according to claim 23, wherein repeating the temporal gating comprises using a same value of N for each repetition, and a bandwidth of the filter, defined as full width at half maximum, is less than the average data unit transmission rate divided by N, but greater than or equal to 70% of the average data unit transmission rate divided by N.

28. A method according to claim 23, wherein repeating the temporal gating comprises using a same value of N for each repetition, and a bandwidth of the filter, defined as full width at half maximum, is less than 70% of the average data unit

transmission rate divided by N, but greater than or equal to 50% of the average data unit transmission rate divided by N.

29. A method according to claim 23, wherein repeating the temporal gating comprises using a same value of N for each repetition, and a bandwidth of the filter, defined as full width at half maximum, is less than 50% of the average data unit transmission rate divided by N, but greater than or equal to 30% of the average data unit transmission rate divided by N.

30. A method according to claim 23, wherein repeating the temporal gating comprises using a same value of N for each repetition, and a bandwidth of the filter, defined as full width at half maximum, is less than 30% of the average data unit transmission rate divided by N.

31. A method according to claim 1, wherein measuring comprises measuring with only one detector.

32. A method according to claim 1, wherein the consecutive measurements begin at times which differ by at least two times the shortest interval.

33. A method according to claim 32, wherein the consecutive measurements begin at times which differ by at least five times the shortest interval.

34. A method according to claim 3, wherein the consecutive measurements begin at times which differ by at least N/2 times the shortest interval, for the smallest N.

35. A method according to claim 34, wherein the consecutive measurements begin at times which differ by at least N times the shortest interval, for the smallest N.

36. A method according to claim 3, wherein the consecutive measurements begin at times which differ by at most 10 times the shortest interval.

37. A method according to claim 6, wherein calculating an expected noiseless result for a measurement comprises:

a) calculating a set of expected results, one for each member of a set of possible sequences of data units, each data unit having one of the discrete set of amplitudes; and

b) determining which result from the set of expected results is closest to the actual result of said measurement.

38. A method according to claim 37, wherein repeating gating the signal comprises using a same value of N for each repetition, and the set of possible sequences of data units comprises all of the possible sequences of N data units, each data unit having one of the discrete set of amplitudes.

39. A method according to claim 3, wherein measuring at least once comprises making a first measurement and a second measurement for each of a plurality of the sequences.

40. A method according to claim 39, wherein estimating the OSNR comprises:

a) grouping the plurality of the sequences into clusters, according to a distribution of the results of the first and second measurements for each sequence in the plurality;

b) calculating a spread of the sequences in each cluster; and

c) using the spread of the sequences in at least one cluster to estimate the OSNR.

41. A method according to claim 40, and including storing the measurement results for each sequence in the plurality before grouping the plurality of sequences into clusters, and grouping comprises using the stored results.

42. A method according to claim 41, wherein grouping the sequences comprises using an algorithm which assigns a sequence to clusters based on the measurement results of said sequence and on a distribution of measurement results of previously assigned sequences, and not on the measurement results of other sequences.

43. A method according to claim 40, wherein calculating a spread comprises:

a) calculating a variance of at least one function of first measurement results and second measurement results in said cluster; and

b) setting the spread equal to a function of the at least one variances.

44. A method according to claim 40, and including:

a) analytically calculating the spread in the at least one cluster that would be obtained with a known value of OSNR; and

b) calibrating the relationship between the spread in the at least one cluster and the OSNR, using the calculated spread.

45. A method according to claim 40, and including:

a) experimentally measuring the spread in the at least one cluster that is obtained with a known value of OSNR; and

b) calibrating the relationship between the spread in the at least one cluster and the OSNR, using the experimentally measured spread.

46. A method according to claim 40, wherein the plurality of the sequences comprises a sufficiently large number of the sequences so that at least one of the clusters has at least two sequences.

47. A method according to claim 39, wherein for each sequence in the plurality, the first measurement is made starting at a same first time after the beginning of the transmission of the first data unit in said sequence, and the second measurement is made starting at a same second time after said beginning.

48. A method according to claim 39, wherein for each sequence in the plurality, the first measurement is a measurement of amplitude and the second measurement is a measurement in phase.

49. A method according to claim 39, wherein for each sequence in the plurality, the first and second measurements are measurements of amplitude.

50. A method according to claim 39, wherein for each sequence in the plurality, the first and second measurements are measurements of phase.

51. A method according to claim 5, wherein estimating the OSNR comprises calculating an average value of the differences determined for a plurality of the at least one measurements.

52. A method according to claim 51, wherein the average value is the root mean square of the differences.

53. A method according to claim 51, and including calibrating the relation between the average value and the OSNR by analytically modeling the average value that would be obtained with a known OSNR.

54. A method according to claim 51, and including calibrating the relation between the average value and the OSNR by experimentally finding the average value using a known OSNR.

55. Apparatus adapted for in-channel estimation of the OSNR of a digital signal comprising a series of data units transmitted at a data rate less than or equal to a maximum data rate, each data unit having one of a discrete set of different amplitudes, the apparatus comprising:

a) a gate which gates the digital signal, selectively blocking data units transmitted at some times while allowing data units transmitted at other times to pass through;

b) a filter which filters the gated signal, substantially reducing frequency components at frequencies comparable to the maximum data rate;

c) a detector which makes measurements of the filtered signal; and

d) a data analyzer which is operative to estimate the OSNR using results of the measurements.

56. Apparatus according to claim 55, and including a controller which controls the detector to make measurements during specified intervals of time related to the timing of the gate.

57. Apparatus according to claim 55, wherein the gate is capable of going from a closed state where the data units are substantially blocked, to an almost fully open state where the fraction of admitted signal power is close to its maximum value, in a response time that is less than the time needed to transmit five data units at the maximum data rate.

58. Apparatus according to claim 57, wherein the response time is less than the time needed to transmit one data unit at the maximum data rate.

59. Apparatus according to claim 58, wherein the response time is less than one fifth of the time needed to transmit one data unit at the maximum data rate.

60. Apparatus according to claims 55, wherein the detector is substantially less sensitive at the maximum data rate than it is at substantially lower frequencies.

61. Apparatus according to claim 55, wherein the detector has a measurement repetition time that is longer than the time needed to transmit one data unit at the maximum data rate.

62. Apparatus according to claim 61, wherein the measurement repetition time is longer than the time needed to transmit two data units at the maximum data rate.

63. Apparatus according to claim 62, wherein the measurement repetition time is longer than the time needed to transmit five data units at the maximum data rate.

64. An apparatus according to claim 55, wherein the apparatus is portable, and is adapted to be serve as a OSNR analyzer for a plurality of different optical networks.

65. An optical network comprising:

a) an optical path carrying an optical signal comprising a series of transmitted data units, each data unit having one of a discrete set of different amplitudes;

b) an apparatus for the in-channel estimation of the OSNR, according to claim 55; and

c) a beam divider for diverting a portion of the power of the optical signal from the optical path to the apparatus.

66. An optical network according to claim 65, wherein the beam divider is a partially reflecting substantially flat surface oriented at an oblique angle to the optical path.